

Next Generation Life Support (NGLS): Variable Oxygen Regulator Element

Game Changing Development Program | Space Technology Mission Directorate (STMD)



ANTICIPATED BENEFITS

To NASA funded missions:

The Variable Oxygen Regulator will increase capabilities of next generation portable life support systems (PLSS) for new space suits under development by NASA's Human Exploration and Operations Directorate, Advanced Exploration Systems Program, Advanced Space Suit Project. Although designed for future human exploration missions, the new suit is planned to be flight tested on the International Space Station sometime before the end of the decade.

To NASA unfunded & planned missions:

The Variable Oxygen Regulator will increase capabilities of next generation portable life support systems (PLSS) for new space suits to be used during future human exploration missions to a range of destinations beyond low Earth orbit (LEO), including cis-lunar space, near-Earth asteroids (NEAs), the moon, and Mars and its moons.

DETAILED DESCRIPTION

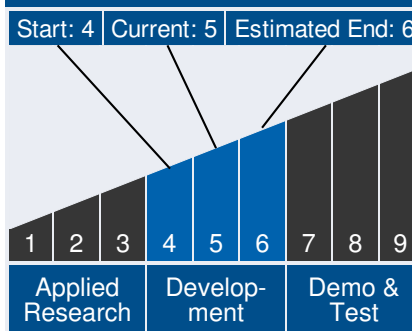
The objective of the Variable Oxygen Regulator Element is to develop an oxygen-rated, contaminant-tolerant oxygen regulator to control suit pressure with a significantly increased number of pressure set points as compared to the state-of-the-art. Using a motor-driven actuator, it allows for continuous control of suit pressure over the range of 0-8.4 psid, compared to only 2 setpoints for the state of the art (~0.9 & 4.3). The enhanced performance will facilitate and improve EVA operations and prebreathe protocols, allow regulation of suit pressure to match different vehicle pressures including integration with suit ports, allow for in-suit decompression sickness treatment, minimize or eliminate prebreathe durations prior to an EVA, and provide the flexibility to run variable pressure profiles during an EVA. Significant accomplishments since the beginning of the project include: Design and fabrication of second generation hardware



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Technology Maturity



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(VOR 2.0). A total of three units were completed. Integration of two VOR 2.0 test articles as part of the Primary and Secondary Oxygen Assemblies of the Portable Life Support System (PLSS) 2.0 test article and initiation of performance testing as part of integrated tests. The VOR is expected to be at a TRL of 5 at the completion of this testing. Completion of oxygen and contaminant compatibility testing at NASA's White Sands Test Facility (WSTF). The regulator used for this test was cleaned and refurbished and is being used for simulated flight environments testing (vibration, vacuum, gravity orientation, etc.) which will advance the maturity of the hardware toward TRL 6. Design of third generation (VOR 3.0) hardware. Differences between VOR 1.0, 2.0 and 3.0 are given in the table below. Fabrication of two VOR 3.0 test articles are expected to be completed during the first part of 2015. This hardware will be delivered to our NASA customer, the Advanced Exploration Systems Advanced Space Suit Project for integration into PLSS 2.5 and later test articles. The technology will be considered at TRL 6 when integrated testing has been completed. Table: Comparison of first (1.0), second (2.0) and third (3.0) generation variable oxygen regulator hardware. VOR

1.0	VOR
2.0	VOR 3.0 • Aluminum
Body	• Monel
Body	• Monel Body, improved design
• Bench-top prototype	• Improved packaging
and size	• Flight-like unit • Rated for nitrogen or
air	• Rated for 100% oxygen
for 100% oxygen	• Rated
Contamination tolerant	• Contamination tolerant
• COTS components	• Improved
components	• Flight qualifiable components
• Improved controller w/interlocks	• Vacuum/ambient
environment	• Relevant environment
Relevant environment	• TRL 4



1 Conference Paper
1 Success Story

Management Team

Program Executive:

- Lanetra Tate

Program Manager:

- Mary Wusk

Project Manager:

- Daniel Barta

Principal Investigator:

- Marlon Cox

Co-Investigator:

- John Owczarczak

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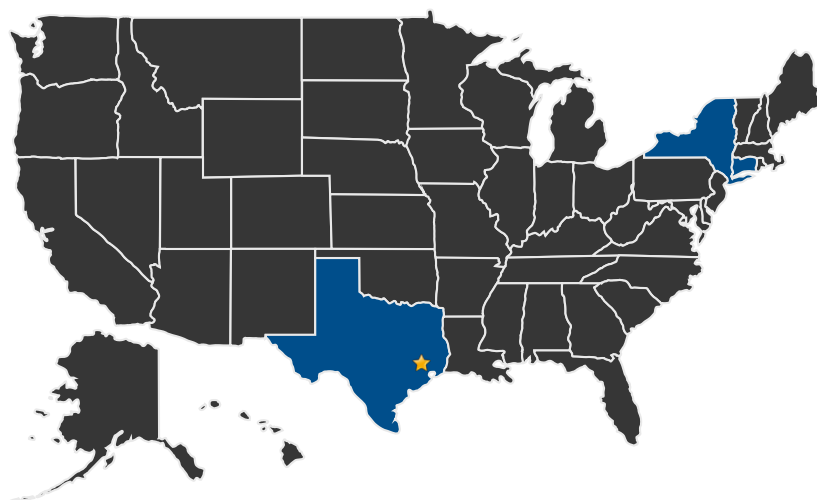
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TRL 5-6

• TRL 6

U.S. WORK LOCATIONS AND KEY PARTNERS



■ U.S. States
With Work

★ Lead Center:
Johnson Space Center

Other Organizations Performing Work:

- Cobham Life Support
- United Technologies Aerospace Systems

Contributing Partners:

- HEOMD Advanced Exploration Systems

LATEST SUCCESS STORY

Technology Infusion Story for Variable Oxygen Regulator

This document gives a top-level overview of the Variable Oxygen Regulator and its infusion to the Advanced Exploration Systems Program for use in the Portable Life Support System test articles for the Advanced Space Suit Project.

Technology Areas

Primary Technology Area:

Human Health, Life Support, and Habitation Systems (TA 6)

- └ Extravehicular Activity Systems (TA 6.2)
 - └ Portable Life Support System (TA 6.2.2)
 - └ Portable Life Support System (PLSS) Pressure Sensor (TA 6.2.2.5)

Secondary Technology Area:

Human Health, Life Support, and Habitation Systems (TA 6)

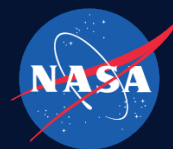
- └ Environmental Monitoring, Safety, and Emergency Response (TA 6.4)

Additional Technology Areas:

Human Exploration Destination Systems (TA 7)

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Technology Need

The exploration of space beyond lower earth orbit will require enhanced capabilities for portable life support systems for new space suits. Missions such as exploring Mars, its moon, and other deep space destinations will last several years. This will result in a significant increase in extravehicular activity and require a suit with more flexibility, robustness, and air flow optimization.

Description

The objective of the Variable Oxygen Regulator Element is to develop an oxygen-rated, contaminant-tolerant oxygen regulator to control suit pressure with a significantly increased number of pressure set points. The enhanced performance will facilitate and improve EVA operations, allow regulation of suit pressure to match different vehicle pressures, and allow for in-suit decompression sickness treatment.

Infusion

Developed by the Next Generation Life Support Project, under the Game Changing Development Program within the Space Technology Mission Directorate. The Variable Oxygen Regulator will increase capabilities of portable life support systems (PLSS) for new space suits under development by NASA's Human Exploration and Operations Directorate, Advanced Exploration Systems Program, and Advanced Space Suit Project. There is a collaboration between the Next Generation Life Support Project, and the Extravehicular Project Office, under Human Exploration and Operations Directorate Advanced Exploration System's Program for development and infusion of technologies for the next generation Extravehicular Mobility Unit (space suit).

Solution

The VOR is a dual-stage regulator in which the second stage uses a stepper motor to control the amount of compression on a spring that is balanced against gas pressure and then controls the size of the orifice that feeds gas into the suit. Using a motor-driven actuator, this dual-stage regulator allows, for the first time, continuous control of suit pressure over a wider range of set points. Resulting in higher levels of flexibility and safety for extravehicular activity.

Benefit

Pre-breath protocols to prevent "the bends" could be performed within the suit, decreasing extravehicular activity preparation time and allowing for more rapid deployment. The suit will have flexibility to integrate across various spacecraft regardless of cabin pressure. The regulator is robust and tolerant of contamination. It will withstand combustion events and retain enough

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capability after first-stage failure to return an astronaut back to the spacecraft safely.

ELEMENT LIBRARY

Conference Papers

- Next Generation Life Support Project Status
 - (<http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140008286.pdf>)

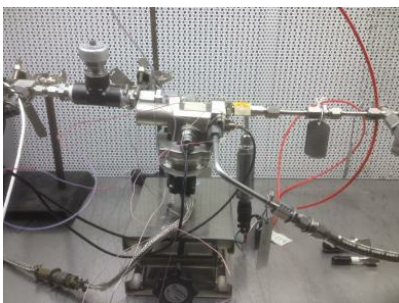
Success Stories

- Technology Infusion Story for Variable Oxygen Regulator
 - (<http://techport.nasa.gov:80/file/16706>)

IMAGE GALLERY



Variable Oxygen Regulator (VOR) 3.0 with VOR Engineer Marlon Cox at time of hardware delivery



Variable Oxygen Regulator (center) undergoing oxygen compatibility and contaminant testing



Variable Oxygen Regulators 2.0 Units 001 and 002 shortly after fabrication and prior to integration into the PLSS 2.0 Test Article

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DETAILS FOR TECHNOLOGY 1

Technology Title

Next Generation Life Support: Variable Oxygen Regulator (VOR)

Technology Description

This technology is categorized as a hardware assembly for manned spaceflight

The Variable Oxygen Regulator (VOR) is an oxygen-rated, contaminant-tolerant oxygen regulator for space suit pressure control, with a significantly increased number of pressure set points and range as compared to the state-of-the-art. The current EMU only has two settings that are mechanically controlled through an intricate mechanical linkage. The VOR is a dual-stage regulator in which the second stage uses a stepper motor to control the amount of compression on a spring that is balanced against gas pressure and then controls the size of the orifice that feeds gas into the suit. Using a motor-driven actuator, it allows for continuous control of suit pressure over the range of 0-8.4 psid, compared to the 2 setpoints (~0.9 & 4.3) of the state-of-the-art. The enhanced performance will facilitate and improve EVA operations and prebreathe protocols, allow regulation of suit pressure to match different vehicle pressures including integration with suit ports, allow for in-suit decompression sickness treatment, minimize or eliminate prebreathe durations prior to an EVA, and provide the flexibility to run variable pressure profiles during an EVA.

Table: Comparison of first (1.0), second (2.0) and third (3.0) generation variable oxygen regulator hardware.

VOR 1.0	VOR 2.0	VOR 3.0
• Aluminum Body	• Monel Body	• Monel, improved design
• Bench-top prototype	• Improved packaging, size	• Flight-like unit
• Rated for nitrogen or air	• Rated for 100% oxygen	• Rated for 100% oxygen
	• Contamination tolerant	• Contamination tolerant
• COTS components	• Improved components	• Flight qualifiable components
		• Controller w/interlocks
• Vacuum/ambient	• Relevant environment	• Relevant environment
• TRL 4	• TRL 5-6	• TRL 6

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Capabilities Provided

- Continuous control of suit pressure over a wider range of set points (0-8.4 psid) resulting in higher levels of flexibility and safety for extra-vehicular activity.
- Precise pressure set point control to reduce crew fatigue & consumables.
- Capability to perform pre-breath protocols within the suit, decreasing preparation time and allowing for more rapid deployment.
- Pressure control and range to allow for treatment of decompression sickness within the suit.
- Flexibility to integrate across various spacecraft and missions of the future, regardless of cabin pressure, including designs that include use of "suit ports".
- Robustness and tolerance to contamination. Ability to withstand combustion events and retain enough capability after first-stage failure to return an astronaut back to the spacecraft safely.

Potential Applications

This regulator has been identified for use in the portable life support system (PLSS) for the next generation space suit under development by the NASA's Human Exploration and Operations Directorate Advanced Exploration Systems Advanced Space Suit Project.

Performance Metrics

Metric	Unit	Quantity
Pressure Settings	#	7,400
Pressure Range	psid	0-8.4
Contamination Tolerance	mg/ft2	100
Mass	lb	3.96